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Regional Analysis of Housing Price Bubbles and Their Determinants in the Czech Republic*

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Abstract

In this article we focus on factors affecting property prices in the Czech regions. We apply an empirical analysis to identify periods of property price overvaluation by three alternative approaches: using ratios related to house prices (price-to-income and price--to-rent), using simple analysis of time trends in regional dimension (HP filter) and using panel regression. The analysis identified overvalued property prices in 2002/2003 and partly also in 2007/2008. Compared to simple HP filters in the panel regression the size of the housing price overvaluation in 2007/2008 was relatively low, as the rise in property prices in this period was largely determined by fundamentals. Looking across individual region, there is apparent tendency for higher degree of overvaluation in regions with higher property prices. The only exception from this rule is Prague, which, as a capital city, seems to have many "specific" features.

1. Introduction

Housing prices proved to be a very important factor during the recent financial crisis. Their explosive growth and busts in combination with the mispricing of subprime mortgage loans are usually mentioned among the most important factors of this crisis (see, for example, Calomiris et al., 2008). Therefore, an understanding of housing price determinants is of crucial importance for central banks. The effect of asset price bubbles on the functioning of the economy can distort the economic and investment decisions of individual economic agents. Their impact can pass through to the housing market via: (i) household consumption through the wealth channel (growth in the prices of property and financial assets held by households is perceived as growth in wealth and consumption financing sources); (ii) the banking sector balance sheet (property prices often serve as collateral in lending operations).[1] These effects differ in strength over time and across economies, but they affect the real economy all the same.[2] What is more, the economic literature does not offer clear recommendations regarding the degree of activity and preventiveness of central bank

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[1] If property prices rise, the probable loss from selling the collateral on a mortgage loan decreases, which, in turn, notionally increases the bank's capital and allows it to expand its investments and loans. However, a slump in property prices can lead to credit constraints, a credit crunch, and a negative impact on economic activity. Housing price busts might negatively influence the balance sheets of the banking sector via an increase of the Probability of Default (PD) and Loss Given Default (LGD) both for housing loans and for loans to the construction industry and to developers.

action – see, for example, Roubini (2006) and Posen (2006) and, for an application to transition economies, Frait and Komárek (2007).

In addition to the aforementioned wealth and banking sector balance sheet channels a change in the situation on the housing market might influence the economy via its impact on the mobility of the labor force and thus via the flexibility of the supply side. Furthermore, historical experience shows that the effects when housing market bubbles suddenly burst are accompanied by larger output losses and last longer on average (4 years) than those when stock market bubbles burst (1.5 years).[3] Housing market bubbles pose a greater threat to the financial stability of a country /region if mortgage loans account for a large proportion of total loans (see, for example, Helbling and Terrones, 2003a,b; Bordo and Jeanne, 2002; or Reinhart and Rogoff, 2009).

The theories and theoretical models of the housing market are, however, different to those for both standard goods and financial assets, as housing goods have the dual nature of commodities and investment assets. Housing goods are also specific due to their durability, their fixation to a specific location and heterogeneity, the relatively high down payment related to the purchase of a house (implying that the buyer's liquidity and liquidity constraints play a role here), and the existence of a secondary market (see Miles, 1995). Therefore, the housing market is usually viewed as being segmented into different connected markets. The theoretical models of the housing market usually suppose that it consists of two markets – one for the stock of existing houses, which determines the price of houses, and another for the flow of new construction, which determines the level of new investment (see Poterba, 1984).

As far as empirical research on housing prices and their relation to the macroeconomy is concerned, the research is relatively extensive for developed countries. An overview of empirical studies is given in Girouard, Kennedy, Noord, and André (2006). Some of the studies use a structural vector autoregression framework (for example, Tsatsaronis and Zhu, 2004). Similarly, Iacoviello (2000) uses structural VAR analysis with a five-dimensional VAR (with real income, real money balances, the real housing price index, the short-term nominal interest rate, and consumer price inflation) for six European countries. Adalid and Detken (2007) use a panel housing price model for 18 OECD countries to analyze the relation of housing prices during boom periods and money growth. They provide evidence for regime shift during boom periods. Noord (2006) tries to calculate the probability of a peak in housing prices in reaction to an increase in interest rates for 17 OECD countries using PROBIT analysis for the period 1970–2005. Girouard et al. (2006) and McCarthy and Peach (2004) try to evaluate the fundamental price from price-to-income and price-to-rent ratios. Rae and Noord (2006) use a relatively simple two-equation approach (one equation for the market for new houses, the second for the market in "second-hand" houses) for the case of Ireland. A similar approach is applied by Hakfoort and Matysiak (1997) for the case of the Netherlands. Girouard and Blondal (2001) try to relate the development of housing prices to household consumption (the wealth effect).

Contrary to the developed countries, research for the Central European countries remains thin on the ground. For the Czech Republic, an analysis of price-to-in-

[2] According to many studies (e.g., Bordo and Jeanne, 2002; Borio and Lowe, 2002), credit booms and asset price busts have had grave financial and economic consequences leading to financial crises in emerging markets.

[3] Helbling and Terrones (2003a).

come and price-to-rent ratios is conducted in the CNB's Financial Stability Reports (CNB, 2009–2010). Čadil (2009) applied the price-to-income ratio and then used VAR analysis to identify the possibility of a bubble on the Czech housing market for the period 1998–2006 for both apartment and family house prices. Zemčík (2011) applied the present value model and panel Granger causality techniques to information on prices and rents to identify bubbles. Hlaváček and Komárek (2009, 2010) applied both price-to-income and price-to-rent ratios, supplementing them with econometric analysis in order to identify the equilibrium path of the Czech housing market. Lux and Sunega (2003) try to assess the equilibrium rent for the case of rent deregulation and try to simulate the effects of this deregulation mainly on the social costs of the state. Lux and Sunega (2010) applied both price-to-income and price-to-rent ratios as well as error correction models for quarterly data for the Czech Republic.

The goal this article is twofold. Firstly, we would like to asses what were the factors determining the growth of prices in the Czech Republic in period 1998–2009. This could allow for creating scenarios of the future housing price developments like the macro based housing price scenarios within banking sector stress testing exercises conducted by the Czech National Bank (see CNB, 2010). Secondly, as we define an asset price bubble as an explosive and asymmetrical deviation of the market price of a housing asset from its fundamental value that has the potential to correct suddenly and sharply, this approach would allow us to asses the sustainability of the housing prices growth in the Czech Republic and the potential for housing price bubbles. We apply three alternative approaches to determining "equilibrium prices" or periods with housing price overvaluation. In the first approach we use simple indicators of housing price sustainability, such as the price-to-income and price-to-rent ratios. In the second approach we determine the misalignment of quarterly housing prices by means of the Hodrick-Prescott (HP) filter. In the third approach, we apply panel regression analysis on annual data for 1998–2008, with property transfer prices in the individual Czech regions as the dependent variable.[4] As our previous studies (see Hlaváček and Komárek, 2010) have shown that the housing prices have important regional element, we applied regional approach in our analysis. This is also our value added compared to the previous studies that were oriented almost solely on the Czech Republic as a whole.

The article is organized as follows. Section 2 discusses the factors influencing house prices that were included in the empirical analysis. In Section 3 we compare different sources of real estate data for the Czech Republic. In Section 4 we construct simple indicators of housing price sustainability. Section 5 analyzes these single indicators from an international perspective. Section 6 shows the results for the identification of asset price bubbles in the Czech regions using the HP filter. Section 7 presents the results of the panel data analysis of housing prices in the Czech regions. Section 8 concludes.

2. Factors Determining Property Prices

The fundamental factors determining property prices in the Czech Republic on which the quantitative analysis below is performed can traditionally be divided into supply and demand factors (see, for example, HM Treasury, 2003, or Égert and Mihaljek, 2008). Compared to the other studies applied to the Czech Republic's hous-

[4] Égert and Mihaljek (2008) performed a similar analysis across the countries of the Central European region.

ing market (Čadil, 2009, and Zemčík, 2011) we opted to include as wide a set of explanatory variables that might be linked to house prices as possible. This was motivated by the nature of the real estate bubble discussed in Section 1. As we define a housing bubble as being the part of house prices that cannot be explained by macroeconomic fundamentals, the omission of some potentially significant factor of housing prices could lead to a bubble being identified even in a situation where prices could easily be explained by this factor.

2.1 Supply Factors

Supply on the housing market is generally driven primarily by the profitability of the construction business and is regarded as sticky in the short run (see, for example, Poterba, 1984). The housing market is often divided into two segments: the segment of existing housing with inelastic supply, where the price is being determined, and the segment of new housing construction, where the price determines the amount of new construction. Supply in the existing housing market can be proxied using the saturation of housing needs (the number of apartments per 1,000 inhabitants) or the dynamics thereof (the number of newly completed apartments). Higher saturation of housing needs should lead, ceteris paribus, to lower upward pressure on apartment prices.

The supply factors also include the majority of cost factors, such as building plot prices or building construction costs. Building construction costs can be proxied using "apartment construction prices" which aggregate the total projected construction investment costs.[5] A rise in the costs of acquiring a new apartment should, at a given level of demand, lead to a rise in the value of existing apartments. Supply factors often pass through to property prices with a long lag, due to the long time it takes to prepare and actually implement a construction project.

2.2 Demand Factors

Demand for property is determined primarily by households' disposable income, the main component of which is wages and salaries. They affect both the accumulation of savings and wealth by households and the availability and riskiness of housing loans. Other labor market factors that can influence property prices include the unemployment rate, the economic activity rate of the population, and the number of vacancies. These factors mostly affect disposable incomes either directly (lower unemployment and a higher economic activity rate of the population mean higher disposable income of households at any given wage level) or indirectly via labor force mobility (migration in search of work). With the exception of unemployment, growth in labor market factors should lead to growth in apartment prices.

Apartment prices can also be affected by various demographic factors: linked with the aforementioned labor market factors is population growth due to migration;

[5] Apartment construction prices are provided by the Czech Statistical Office (see CZSO, 2008). They reflect the total investment cost of building new property (at least the amount stated on planning permission application documents, i.e., the tentative costs of the build, including equipment) and they do not include expenditure on the building plot. They are, however, often distant from the real market price and are usually lower. Another possibility is to use the construction output price index. Its advantage compared to apartment construction prices is its higher frequency (monthly compared to yearly). On the other hand, the construction output price index is not available in regional coverage, unlike apartment construction prices.

natural population growth should act in the same direction. Property price growth should also be fostered by a higher divorce rate, as most divorces turn one household into two, thus giving rise to a need for a new dwelling. The marriage rate can act in the same direction, as a wedding often establishes a completely new household. Demand for housing can also be affected by the age structure of the population (people of productive age should usually form the majority of demand for new housing), which, however, is reflected in the economic activity rate of the population.

The major factors of property price growth have recently also included the development of the financial market. This is being reflected primarily in growth in housing loans and is reducing the liquidity constraints on households when acquiring their own housing and should therefore be pushing property prices upward. The mortgage interest rate (proxied by the one-year money market rate) acts in the opposite direction, as growth in the mortgage rate makes loan financing of property purchases less attractive and increases households' repayments of existing loans.[6] Demand from abroad can affect demand for housing quite strongly.

Demand for property can also be affected by market rents, growth of which tends to lead to rising apartment prices. This factor reflects substitution between rental and ownership housing, as rising rents motivate households to buy a flat of their own and therefore increase demand for owner occupied housing. The level of rents also affects investment in housing for speculative reasons, as growth in rents ceteris paribus increases the returns on such investment and leads to rising demand for apartments. The dependence between apartment prices and market rents can go in either direction, of course. The aforementioned substitution between rents and home ownership may therefore mean that, conversely, a rise in apartment prices will lead to a rise in market rents (home ownership will become less affordable, causing demand for rented accommodation to rise).[7] Besides that, one needs to take into account the decisions of owners of rental properties as to whether to continue renting the property or whether to sell it (as happened in the past with many municipal flats with regulated rents). Given the limited length of the time series, however, we do not examine the direction of the causality between apartment prices and other variables in our analysis.[8]

3. Sources of Real Estate Data in the Czech Republic

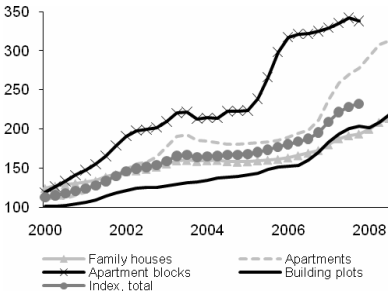
Any considerations about the equilibrium growth of housing prices and about possible negative shocks to them are necessarily influenced by the data source selected. Compared to "standard" markets the real estate market is rather specific, as

[6] Unfortunately for the Czech mortgage market there is no indicator of the credit market conditions going beyond the simple interpretation of interest rates (such as the IMF Mortgage Market Indicator). Moreover, even the data on interest rates on housing loans are available only for 2004 and therefore we had to use just the money market rate, which does not include information on the spread of housing loans.

[7] This relation implicitly considers housing as an investment good. However, preference for home-ownership might be influenced by other factors than just by comparing rents and user costs. The particularities of rental sector (for example, pension schemes) and particularities behind the preferences for owner-occupied housing are also important in this respect. Therefore the full substitution between rental and owner-occupied housing has been only rarely confirmed empirically.

[8] See Hurlin (2004) and Hurlin and Venet (2004) who show the number of observations needed to conduct panel data Granger causality tests.

Figure 1 Property Prices – Transfer Prices According to Tax Returns



Notes: Absolute index, 1999 Q1 = 100; 2008 and 2009 data preliminary or calculated from supply prices (for prices of apartments and building plots).

Sources: CZSO, and authors´ calculation

real estate is to a large extent a heterogeneous type of good. The price of individual real estate depends on a number of characteristics, such as its type (apartments compared to family houses), its size, its age and quality, its equipment, what floor the apartment is on, the view from the apartment, and other similar characteristics that are difficult to measure. A specific feature of the real estate market is the virtual impossibility of transferring a property from one location to another, coupled with highly inelastic supply (the number of newly constructed apartments is just a small fraction of the overall housing stock[9]). Real estate prices are thus often determined regionally; within a given region other location characteristics are of high importance (e.g., downtown relative to suburb). This extreme heterogeneity of the real estate market of course makes construction of the housing price indicator complicated, while different data sources might lead to different conclusions.

In the Czech Republic there are several possible sources of data series on real estate prices. The main data sources are listed in the *table in Appendix 1*. Generally, one can distinguish two types of real estate prices – transfer prices and supply prices.[10] Real estate transfer prices are the closest to actual market prices in terms of methodology. The only available source of real property transfer prices in the Czech Republic is the Czech Statistical Office (see CZSO, 2009), which uses Ministry of Finance statistics from property transfer tax returns (for the evolution of these prices see *Figure 1*).

The advantage of this source is its completeness – almost all transfers of second hand real property against payment are subject to tax.[11] Advantage of this data

[9] Even in 2007, when the number of completions recorded its highest level since the early 1990s, the ratio of the number of newly constructed apartments to the total housing stock was only 1%. There are massive regional differences in the intensity of housing construction (higher construction in Prague and in Central Bohemia, for which the number of completions per 1,000 inhabitants is more than two and a half times that in the rest of the Czech Republic). However, even for the regions with the highest construction the numbers of completed apartments do not exceed 2% of the housing stock.

[10] Sometimes „transfer prices" are labeled as „transaction prices" or „realized prices".

[11] The CSZO excludes both unpaid transfers (like gifts or patrimony) of residential property prices and transfers against payment that are not based on standard "market conditions". Example of excluded transfers is the transfer arising from privatization of municipal housing to occupants with regulated rent contracts.

source is also its relatively wide coverage across all major districts, according to size of municipality, age of the given real estate and types of real estate (apartments, family houses, apartment blocks, building plots, and garages). Another advantage is that this source of data forms the longest time series of all the available data sources (since 1998). However, a big disadvantage of this data source is its long delay to publication of final data (almost one year[12]). Tax optimization by the respondents might also influence the prices reported. Another disadvantage is that this index only includes information on the prices of transfers of already existing real estate. Information on the prices of new houses or apartments is not included, as they are not subject to property transfer tax (they are subject to value added tax).

The second type of apartment prices available is "supply prices". These prices are usually based on the bid prices of real estate agencies. Consequently, they are supposed to be higher than transfer prices. The advantage of this source of data is the swiftness of their publication. The obvious disadvantage is that the evolution of supply prices might only reflect changes in the margins of real estate agencies.[13] These bid prices might be also biased by older advertisements with unrealistically high prices that survive in the list of advertisements for a longer time than advertisements with prices that are actually traded.

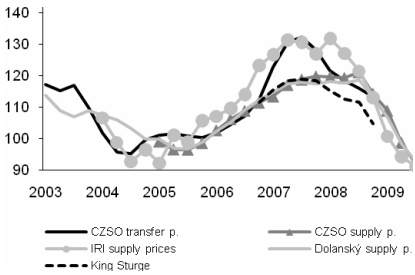
The longest data series of supply prices in the Czech Republic has been published by the Institute for Regional Information (IRI) since 2000. The IRI uses the prices of a "standard apartment".[14] On the one hand, this enables us to avoid problems with changes in the structure of the housing stock and the need to change weighting schemes. On the other hand, one loses information about price developments outside this relatively thin market segment. For this reason this index often shows different dynamics compared to alternative indexes (see *Figures 3* and *4*). The advantage of IRI supply prices is that the IRI also publishes supply market rents. This enables us to construct an apartment rental yield index or price-to-rent indexes, which are the basic indicators of the sustainability of housing prices (see section 4). Another important primary source of real estate supply prices is the indexes constructed by the team around Professor Dolanský, which, starting from 2002, are published at monthly frequency in the journal "Realit". This source covers apartment prices, family house prices, and building plot prices. Since 2007 it has also been publishing market rents for Prague. Apartment prices are classified in detail for different districts of Prague, the data for apartment prices outside Prague are not complete (some regional capitals are missing). Apartment prices from this database are also the primary source for the apartment supply prices published quarterly by the CZSO since 2004. An interesting source of apartment prices is the "Czech Republic Resi-

[12] For apartment prices and family house prices, however, the Czech Statistical Office publishes estimates that are continuously updated with a lag of approximately one quarter. The final data, however, are often quite distant from those estimates.

[13] For individual advertisements it is often not clear whether or not the price bid includes the real estate agency's commission. This might significantly influence the level and dynamics of prices, as these margins could have a significant cyclical component. The final price might differ from the advertised price due to different discounts, promotions, etc.

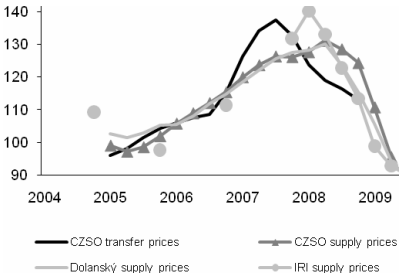
[14] IRI limits itself to prices of "1st category" apartments that are either cooperative or owner-occupied with a floor space of 68 m^2 and amortization of approximately 40% in a conventional and not suburban location.

Figure 2 Apartment Prices – Prague (year-on-year indexes)



Sources: CZSO; IRI; Realit; King Sturge

Figure 3 Apartment Prices – Rest of Czech Republic (year-on-year indexes)



Sources: CZSO; IRI; Realit

dential Report" published by the real estate advisory company King Sturge (see King Sturge, 2009) that differentiates between second hand and new real estate. This source of data looks in detail at apartments as well as family houses in Prague and its districts; however, data on other regions of the Czech Republic are limited. Besides the above-mentioned sources of real estate supply prices there are several other data published that are discussed in the press (e.g. data from real estate agencies like AAA byty or Lexxus). Nevertheless, these data are usually available only for short time series.

The dynamics of apartment prices over the last five years according to different data sources is depicted in *Figures 2* and *3*. From these Figures one can clearly see that the growth in apartment prices shows similar tendencies across the different sources (correlation coefficients between 0.85 and 0.99 – see also *Appendix 2*). Comparing the two figures one can conclude that the size of the year-on-year drop in prices in 2009 according to a given source is negatively linked to the previous growth of prices according to this source in 2006–2008. In other words, the sources that reported the highest price growth for apartments are now reporting the highest price drops in 2009. This is visible, for example, from a comparison of IRI and CZSO supply prices.[15] This might be due to the fact that the IRI covers only a relatively narrow

[15] Or Dolanský supply prices, which correlate strongly with the CZSO ones as the former are the primary data source for the latter.

part of the apartment market with lower prices that are more sensitive to changes in the economic situation.

Comparing the CZSO transfer price and supply price dynamics, it seems that the reaction of transfer prices is somehow quicker (see also *Appendix 2* for lagged correlations that illustrate this as well). This might indicate some counter-cyclicality of the margins between supply and transfer prices, with margins shrinking during massive growth in prices and widening during large declines in prices. Comparing *Figures 2* and *3* one can see that during the last period of high price growth there was some convergence tendency for apartment prices between Prague and the rest of the Czech Republic, as prices grew faster in the rest of the Czech Republic than in Prague according to both transfer prices and supply prices.

These stylized facts from *Figures 2* and *3* in combination with the lead/lag correlation matrix from different data sources (see *Appendix 2*) show that CZSO transfer prices often lead the prices from the other data sources. Due to this and due to combination of the most detailed regional coverage and the clearest methodology we decided to use this data source primarily. For the newest data (2009), as well as for some additional information (e.g., rents), we also used the other data sources. We decided to conduct our analysis only for apartment prices and not for the other types of real estate (e.g., family houses). The reasons were threefold. Firstly, apartment prices are the most widely covered by the alternative data sources. This allows us to check the consistency of their price developments and to prolong the data series for supply prices to include the latest data. Secondly, as one can see from *Figure 1*, apartment prices show the most interesting price dynamics and therefore a price bubble is most likely to be identified for them.[16] Thirdly, apartments should be more "homogeneous" than, for example, family houses. This makes the analysis of apartment prices more likely to be successful. However, one has to keep in mind that we describe only part of the real estate market and that we do not opt for analysis of the other segments.[17]

4. Simple Indicators of Housing Price Sustainability

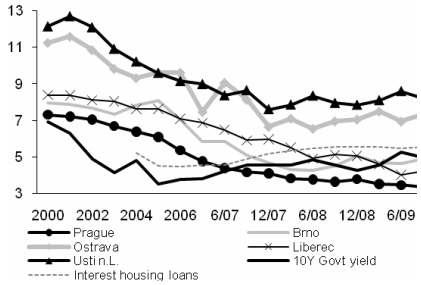
Following OECD (2005) one can quickly visualize the excessiveness of housing prices using simple price-to-income or rental return[18] ratios. The two ratios are depicted in *Figures 4* and *5*. From *Figure 4* one can deduce that for the majority of the Czech regions the rental return ratio was constantly worsening between 2000 and 2008 H1. Until 2005 this worsening was in line with the drop in interest rates, but starting from 2006 the rental return declined further despite rising government bond yields and housing loan interest rates. Thus, the growth in prices in 2006–2008 might have some bubble component according the rental return indicator. A drop in prices

[16] The prices of apartment blocks recorded even higher growth than apartment prices. However, the number of transfers is low compared to the other types of real estate (with a much higher price per transfer).

[17] For example, for the period 2005–2007 the number of used apartment transfers formed only 56% of all transfers of used residential units (apartments and family houses), their share in the volume of transactions was 49%. There were also significant regional differences for these shares. For example, in Prague apartments form 95% of all transactions and 89% of their volume, while the respective numbers for Central Bohemia are 45% and 33%.

[18] The rental return ratio is the inverse of the alternatively used price-to-rent ratio. Its advantage is that it can be compared directly with interest rates in the economy.

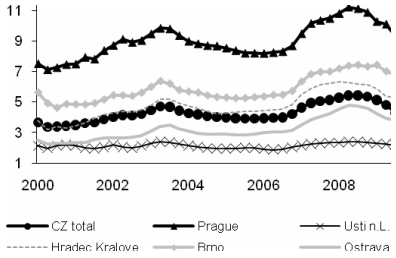
Figure 4 Rental Returns (ratio of yearly rent to apartment price)



Notes: 2009 data preliminary; averages for period in %; comparison with yields on 10Y government bond and housing purchase loan rates.

Sources: IRI supply prices/rents; authors´ calculation

Figure 5 Price-to-Income Ratios (ratio of price of 68 m^2 apartment to moving sum of wage for last four quarters)



Note: 2008/09 data preliminary or calculated from supply prices.

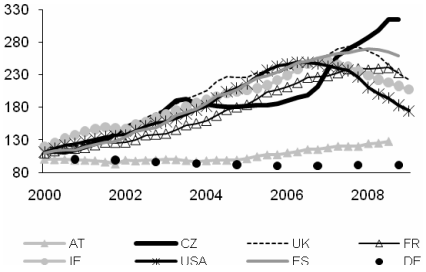
Sources: CZSO transfer prices; authors´ calculation.

in 2009 resulted in an improvement of the rental return indicator for the majority of regions, but for the majority of them it remains below the relevant interest rates.

Similarly, the price-to-income ratio (*Figure 5*) indicates two potential apartment price bubble periods, namely, the start of 2003 and late 2007/early 2008. These periods are those with high price growth (see *Figures 1, 2*, and *3*). For the period 2004–2006 one can see that the housing price bubble might ease relatively easily from the point of view of the price-to-income ratio. During this period, apartment prices were more or less stable and the improvement in the price-to-income ratio was due to wage growth. However, a question arises as to whether this can be repeated in the generally less favorable macroeconomic conditions of the world financial crisis. The improvement in the price-to-income ratio in 2009 was mainly due to apartment price drops. The ratio remains at relatively high levels.

From both the price-to-income and rental return ratios one can also work out which regions are "more risky" from the point of view of these indicators. Looking at the cross-regional dimension of those indicators (*Figures 4* and *5*) it is evident that the worst values are reported for regions with relatively high absolute prices (Prague) and the most favorable values for regions with relatively low absolute prices (Ústí nad Labem Region, and Ostrava Region).

Figure 6 International Comparisons of Apartment Prices in Selected Countries (index 1999 Q1=100)



Notes: AT – Austria, AU – Australia, CA – Canada, CZ – Czech Republic, DE – Germany, DK – Denmark, ES – Spain, FI – Finland, FR – France, CH – Switzerland, IE – Ireland, IT – Italy, JP – Japan, KO – Korea, NO – Norway, NZ – New Zealand, SE – Sweden, UK – United Kingdom, USA – United States

Sources: BIS; CZSO; Case and Shiller (US); and Nationwide (UK)

Application of simple ratios mentioned above suffers from several drawbacks. For instance: (i) they produce high variability in the indication of non-equilibrium states; (ii) they do not directly take into consideration movements other fundamentals like interest rates and (iii) their time series still have short histories, particularly in the case of transition economy property markets.[19]

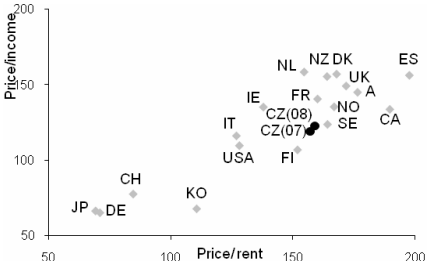
5. Single Indicators from an International Perspective

One way how to identify property price bubbles in the Czech Republic is to compare its housing price developments to those in countries where such prices had surged in the previous decade and that experienced major falls of those prices during recent financial crises (see *Figure 6*). For example the housing prices in the USA fell by 20% in 2008, in the Great Britain by 15%, in Ireland by 10%, in Spain by 3% and the prices continued to decline in course of 2009 in those countries. Compared to aforementioned countries the growth of the housing prices rather lacked in the Czech Republic in period 2004–2006, their growth in 2007 could be thus viewed as return to "normal" level. On the other hand, the fact that the housing prices continued to grow in the CR in the 2008 despite the above mentioned sizable drops of housing prices in other countries and despite effects of the financial crisis on the Czech economy indicates, that the housing price growth might have had bubble component in this year. This is supported by the fact that in the developed economics that are our neighbors and biggest trade partners (Germany and Austria) the housing price growth was rather calm during the whole decade.

On the other hand the comparison with countries included in *Figure 6* is somehow complicated by the fact that those countries have not experienced real convergence in an extent as the Czech Republic. Therefore the part of the growth in housing prices in the Czech Republic could be contributed to convergence character of our economy and catch up to levels usual in the developed countries. Comparison

[19] The relatively high value of the price-to-rent ratio for the Czech Republic (see *Figure 7*) is due, for example, to its very low value at the beginning of the period, linked, among other things, to relatively high nominal interest rates in late 1990ties.

Figure 7 Price-to-Income and Price-to-Rent Ratios in the Cross-Country Perspective (year 2007, long-time average=100)



Notes: AT – Austria, AU – Australia, CA – Canada, CZ – Czech Republic, DE – Germany, DK – Denmark, ES – Spain, FI – Finland, FR – France, CH – Switzerland, IE – Ireland, IT – Italy, JP – Japan, KO – Korea, NO – Norway, NZ – New Zealand, SE – Sweden, UK – United Kingdom, USA – United States

Sources: Datastream; CZSO; IRI; authors' calculations

to comparable countries in the region (e.g. Visegrad countries) is limited by the short time series of the housing data for them.

Appropriateness of the housing price growth in the Czech Republic could be also assessed using international comparison of the *price-to-income* and *price-to-rent ratios* (for definitions see part 4). This comparison (see *Figure 7*) indicates, that in 2006 both these indicators were lower in the Czech Republic than those in countries mentioned above experiencing problems with housing price bubbles.[20] This was true even in 2007, when the quick price growth led to significant worsening of both indicators in the Czech Republic. Further increase of the *price-to-income* and *price-to--rent* indicators in 2008 was relatively mild. Despite decrease of both indicators in countries experiencing already in 2008 housing price drops, situation in the Czech Republic seems to be relatively favorable.

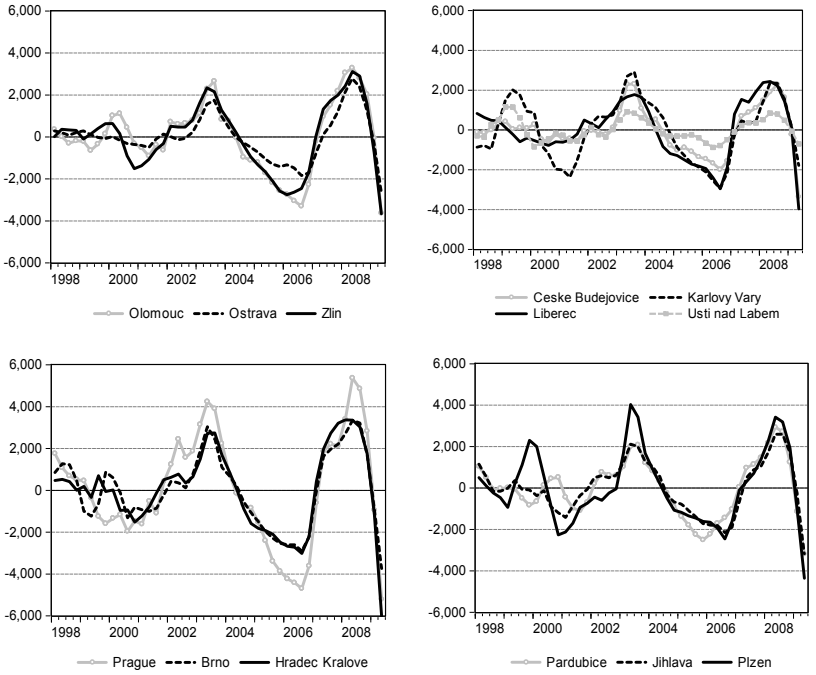
6. Statistical Filters

The statistical filters are one way for identifying misalignment of asset prices. The advantage of this approach is that it is quick and easy to apply. Univariate filters such as the Hodrick-Prescott (HP) filter or alternatively Band-Pass (BP) filter can be used to calculate the trend, which is broadly used in many studies. *Figure 8* [21] shows the outcome from HP filter (with recommended parameter for quarterly data, i. e. $\lambda = 1600$) for Czech regions. The development of misalignment is quite similar among Czech Regions, at the end of 2008 all regions were slightly overvalued. The price drop during 1.H 2009 however led to rapid change to this situation. Currently (2.Q 2009) the housing prices are strongly under valuated. In absolute terms the Ústí nad Labem Region is the most stable (price gap remaining within the range of ap-

[20] However *price-to-income* and *price-to-rent* ratios for the USA were relatively favorable in 2007.This illustrates limitations of the approach evaluating bubbles with use only simple indicators. Excessive growth of the housing prices in the USA was due to other factors than just growth of wages and rents. Property price bubble in the USA was more linked with issues connected with financing of the housing purchase and accessibility of mortgages. This disproportion might be also due to the fact that the source of data for *Figure 7* differs to data used in *Figure 6*.

[21] Individual regions are grouped according to their under/overvaluation in *Figure 10*.

Figure 8 Misalignment in Housing Prices Using Hodrick-Prescott Filter



Notes: + (overvaluation), (-) undervaluation in CZK.
Sources: CZSO, authors´ calculation

proximately +/-1000 CZK), the opposite is the situation in Prague (approximately +/- 5000 CZK). This is of course influenced by the level of prices as the absolute size of misalignment is lower in regions with lower prices. In relative terms (expressed in percents of actual price) the size of misalignment is much similar among all studied regions. This shows the basic flaws of the statistical filters analysis applied to regional data – unless the prices in some region strongly diverge from the other regions, the statistical filters analysis shows quite similar levels of price misalignment among all regions and thus use of regional data does not bring much value added compared to the analysis of the prices aggregated across all regions. This problem could be at least partly fixed by the panel data analysis that is applied in chapter 7 that can identify crucial factors and determinants of the housing price movements at the Czech regions. The results of the statistical filters analysis can be compared with the outcome from panel data analysis (see *Figure 10*). The level of misalignment according to the statistical filters analysis is of course bigger as the panel data analysis relates part of the difference of the housing prices from their HP trend to the fundamental factors. The results presented in *Figure 8* show another crucial flaw of the statistical filters analysis. If we consider the expected effects of the financial crisis on the housing prices, the undervaluation of these prices in 2.Q 2009 seems to be extremely contra-intuitive. This undervaluation is caused partly by the fact that the statistical filters do not account for change of the economic environment at all, they are also

extremely prone to the well known end point bias that is in the current situation even stronger.

7. Panel Data Analysis

The empirical analysis was conducted by means of panel regression across the Czech regions (including and excluding Prague) on annual data for 1998–2008. The explained variable was apartment price growth (aggregate regression) or the apartment price level (panel regression), in real terms in both cases.[22] In empirical calculation we work with unlagged exogenous variables (owing to the short length of the time series used). We also conducted an estimate based on a narrower set of explanatory variables owing to the possible existence of endogeneity of some explanatory variables. Due to the low number of observations we were not able to capture this endogeneity analytically other than by removing variables suspected of endogeneity from the regression. By comparing different versions of the regression we also get some idea of the stability and robustness of our results.

In order to capture analytically the aforementioned heterogeneity of houses as an asset at least partially, we estimated a panel regression for apartment prices covering the individual Czech regions. The results are summarized in *Table 1*, where we included three versions of the regression, keeping in mind the potential endogeneity of some explanatory variables. Therefore, in the second and third columns (CZ – estimate A) we included the full set of variables, while in the fourth and fifth columns (CZ – estimate B) building plot prices and monthly rents were excluded from the regression. Both specifications reported a similar list of significant variables as well as similar signs on those variables. This indicates that endogeneity has not broken the relationships between housing prices and their determinants completely. In the last two columns (CZ excluding Prague – estimate B) we tried to capture the specific nature of Prague as the capital city by removing it from the sample as an outlier. Again, the results of the regression changed only slightly.

To capture the differences in property prices between regions, we used absolute prices in CZK per m^2. However, to eliminate non-stationarity of the residuals, we used two alternative approaches. In the first one, denoted OLS, we used the differences of the apartment prices that are stationary (see *Appendix 3*).[23] By doing this we eliminated fixed effects and therefore we could use just simple OLS regression.[24]

[22] Hlaváček and Komárek (2009a) present a similar analysis for nominal apartment prices.

[23] The statistical tests indicated that it was appropriate to use a panel regression with fixed effects. We tested the panel data for non-stationarity using the Hadri panel unit root test. For results see *Appendix 3*. The discussion of empirical methodology including methodology of the panel data, more detailed discussion of the supplementary tests for stationarity and discussion of the explanatory data (multicolinearity issues and other) could by found in Hlaváček, Komárek (2009b). Hadri test performs a test for stationarity in heterogeneous panel data (Hadri, 2000). This Lagrange Multiplier (LM) test has a null of stationarity and its test statistic is distributed as standard normal under the null. The series may be stationary around a deterministic level, specific to the unit (i.e. a fixed effect) or around a unit-specific deterministic trend. The error process may be assumed to be homoskedastic across the panel, or heteroskedastic across units. The residual-based test is based on the squared partial sum process of residuals from a demeaning (detrending) model of level (trend) stationarity.

[24] Another possibility would be to use fixed-effect regression for apartment prices expressed in differences. However, such regression would have a slightly different interpretation than, for example, regression with fixed effects on housing price levels. Here, the fixed effects would show some systematic differences in apartment price dynamics across regions.

Table 1 Results of Panel Regression

Variable	CZ – Estimate A		CZ – Estimate B		CZ excl. Prague – Estimate B	
Apartment prices	OLS	PR	OLS	PR	OLS	PR
Apartment prices [a]	x	0.938*** *0,074*	x	0.776*** *0,088*	x	0.859*** *0,093*
Building plots prices [b]	0,633 *0,675*	1.223* *0,715*	x	x	x	x
Apartment construction prices [b]	0,016 *0,062*	0,007 *0,064*	0,012 *0,079*	0,001 *0,080*	0,014 *0,082*	0,019 *0,081*
Completed apartments	-1,158 *7,704*	0,402 *9,290*	-16,161 *9,580*	-0,598	-11,456 *9,546*	5,813 *11,649*
No. of apartments per 1,000 inhabitants	-0.148*** *0,059*	-0,031 *0,281*	-0.297*** *0,072*	-0,155 *0,348*	-0.295*** *0,070*	-0,411 *0,404*
Marriages	-0,504 *32,597*	3,006 *46,382*	1,178 *41,270*	-66,890 *56,564*	-3,932 *38,936*	-49,907 *56,277*
Divorces	50.739** *27,595*	82.321** *42,100*	76.245*** *35,077*	75,974 *52,351*	68.843** *34,432*	71,099 *48,059*
Natural population growth	38.941*** *12,261*	70.323*** *22,430*	16,269 *15,306*	56.733** *27,863*	34.292** *15,238*	78.167*** *28,195*
Net migration	3,902 *4,727*	6,983 *5,796*	9.540* *5,978*	15.395** *7,088*	9,479 *6,313*	9,995 *7,594*
Unemployment rate	-1.407*** *0,444*	-2.155*** *0,802*	-2.675*** *0,537*	-4.406*** *0,922*	-2.487*** *0,507*	-4.106*** *0,841*
Economic activity rate of population	-1,005 *0,785*	0,880 *1,291*	-0,512 *0,991*	1,220 *1,602*	-0,636 *1,098*	1,342 *1,582*
Vacancies/labor force	11.958** *5,866*	3,985 *6,952*	13.444* *7,488*	7,303 *8,617*	8,127 *7,310*	2,086 *8,411*
Average monthly wage [b]	1.807*** *0,592*	2.001*** *0,662*	2.756*** *0,741*	3.017*** *0,807*	2.499*** *0,726*	3.179*** *0,776*
Rent per month [b]	102.285*** *12,322*	95.205*** *13,453*	x	x	x	x
Loans [b]	0.048* *0,027*	-0,011 *0,039*	0.071** *0,032*	0,013 *0,043*	0,095 *0,075*	0,044 *0,115*
1Y Pribor	1,515 *1,060*	1,958 *1,250*	2,066 *1,354*	1,311 *1,551*	2,693 *1,378*	1,899 *1,476*

Notes: Cells in grey highlight are the coefficients significant at least at 10% level. *** significant at 1%, ** at 5% and * at 10% level of significance. PR - panel regression; OLS -ordinary least squares regression. Standard errors in italics.
[a] variable lagged by1Q, [b] differences

Sources: CZSO; CNB; IRI

In the second approach (marked PR) we used panel regression with fixed effects on the level of prices and we incorporated apartment prices lagged by one year in the explanatory variables. Not surprisingly, they turned out to be statistically significant, indicating some persistence in apartment prices.[25]

[25] The estimated coefficient here is less than one, so the estimated relation should converge. The explanatory variables that were not stationary in levels (see *Appendix 3*) entered regression in their first differences (depicted by superscript *b* in *Table 1*).

The regression results showed that supply side effects are not an important factor of apartment price growth. The only exception was the influence of the saturation of housing needs in the OLS regressions, which was significant with the correct sign in all three versions of the regression. In the panel regression the effect of a rise in building plot prices had the correct positive sign and was insignificant at the 10% level. Nevertheless, in the case of building plot prices, one can also discuss the direction of the implication between apartment prices and building plot prices or their substitutive relationship with apartment prices as assets. The regression implicitly considers this cost effect, as higher building plot prices lead to higher costs of new apartment construction and higher prices of new apartments. However, one can also consider the opposite effect, where high apartment prices lead to more intensive apartment construction, reflected, in turn, in higher demand for building plots, which, given its low price elasticity, leads to rising prices of building plots. The second component of apartment-building costs, "apartment construction prices," which reflect the costs of building, turned out to be insignificant even though they had the correct sign. This is probably because this price shows little variability between regions as well as over time.

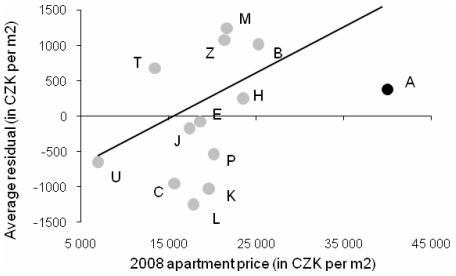
Of the other supply factors, the number of newly completed apartments also proved to be insignificant. This factor had the expected sign only in four specifications (higher completions and higher housing saturation should lead, ceteris paribus, to lower prices). The explanation here may again be the opposite implication, with higher apartment prices – given relatively stable construction costs across regions – leading to higher apartment construction and, in turn, to a higher number of apartments.

Of the demographic factors, the divorce rate proved significant (it was insignificant in only two of the six alternative specifications, and even then it was at the border of the 10% significance level). The sign on it is consistent with intuition, as a higher divorce rate leads to a greater need for housing (a divorce usually gives rise to a new household). A similar effect can be expected for the marriage rate, although it turned out to be statistically insignificant. This might be due to the fact that marriages nowadays take place only if the couple has already solved its housing needs. As for population growth, net migration was significant for two specifications and natural population growth was significant for five cases. Both variables had the expected signs in all specifications; in specification "CZ-B" they shared significance partly.

The majority of the variables relating to the labor market (economic activity rate and number of vacancies) proved to be statistically insignificant (vacancies were significant in only two versions of the OLS, with 5% and 10% significance levels, respectively). This may reflect the generally low labor mobility within the Czech Republic, as relatively few people move in search of work. Labor market imbalances thus tend to be resolved rather by commuting or by the employment of foreign casual workers, whose demand for home ownership is low. The only significant labor market variable, which appeared in the regressions with the logical negative sign, was the rate of unemployment. This might relate also to the lower disposable income of households in regions with higher unemployment rates.

Of the other demand factors, growth in market rent proved significant, reflecting substitution between renting and home ownership. The significance of the coef-

Figure 9 Apartment Price Overvaluation Relative to Apartment Price



Notes: Values shows average residual for time period 1998–2008. A – Prague, S – Central Bohemian Region, C – South Bohemian (České Budějovice) Region, P – Plzeň Region, K – Karlovy Vary Region, U – Ústí nad Labem Region, L – Liberec Region, H – Hradec Králové Region, E – Pardubice Region, M – Olomouc Region, T – Moravian-Silesian (Ostrava) Region, B – South Moravian (Brno) Region, Z – Zlín Region, J – Vysočina (Jihlava) Region.

Sources: CZSO; IRI; CNB; authors´ calculation.

ficient meanwhile confirms the role of the price-to-rent ratio (or *rental-return* ratio) as an important indicator of the stability of apartment price growth. The significance of the price-to-wage ratio was also confirmed, as the coefficient on wage growth was significant at the 1% level with the expected sign. The expected role of housing loans as a major demand mechanism of property price growth was surprisingly not confirmed, as they were significant in only two specifications at the 10% level. This might be due to the "exponential nature" of housing loans in 2002–2008, when they recorded approximately 30% yearly growth irrespective of developments on the housing market. However, the recent developments might indicate that the standard relationship will be restored.

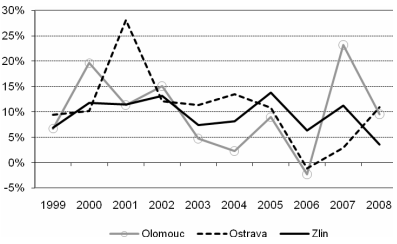
Interest rates, which were used for all regions the same, were not significant in any of our regressions and recorded the opposite sign than expected. The statistical insignificance of interest rates may be due to the fact that we used the interest rate on the interbank market, whereas interest rates on new housing loans would have been economically more meaningful (and the spread between these two rates can change quite significantly over time). Unfortunately, however, we did not have housing loan rates available for the whole time period (figures are only available from 2004 onwards).

The overall statistical properties of the panel regression seem fairly good (see *Table 1*). We succeeded in explaining the variability of prices across regions better than their variability over time, but the difference was not large. The statistics confirm the appropriateness of using the fixed effects model. The F-test of equality of the constants for fixed effects rejects the hypothesis of equality at the 23% level of significance, which at least partly confirms the hypothesis that some regions are specific in nature. For example, one can assume that apartment prices in Prague are, ceteris paribus, higher than in other regions, because Prague is the capital city.

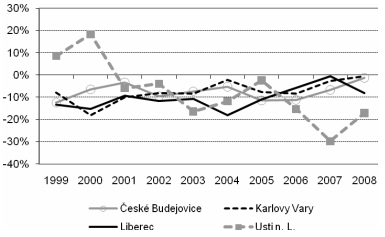
The specific nature of property prices in Prague is confirmed by *Figure 9*, which compares the residuals of the panel regression by regions with prices in those regions. This figure shows that it generally holds that apartment prices in regions with lower prices are undervalued (negative residuals), whereas those in regions with

Figure 10 Misalignment in Housing Prices in Czech Regions

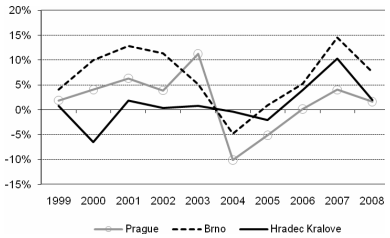
a) Systematically overvalued regions



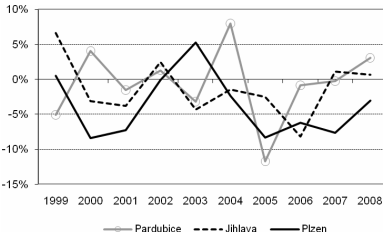
b) Systematically undervalued regions



c) Regions with mostly overvalued prices



d) Regions with mostly undervalued prices



e) Descriptive statistics over time (misalignment in percent of price in given region)

	A	B	C	E	H	J	K	L	O	P	T	U	Z
Average	1.81	6.69	-7.49	-0.63	1.09	-1.25	-7.36	-10.36	9.92	-3.76	10.82	-7.57	9.37
Median	2.89	6.41	-7.01	-0.54	0.78	-2.00	-8.06	-10.79	9.25	-4.65	10.83	-8.86	9.66
Difference 2008-1999	-0.23	3.49	11.14	8.16	1.19	-5.95	7.47	5.42	2.85	-3.61	1.42	-25.67	-3.33
Standard deviation	5.63	5.57	3.47	5.14	4.05	3.94	4.68	4.65	7.38	4.38	7.18	13.09	3.20

higher prices are somewhat overvalued (positive residuals). But in Prague (labeled A in the chart), apartment prices diverge from this positive relationship between the price and the degree of overvaluation, as they were overpriced only marginally despite being approximately two times higher than apartment prices in the rest of the Czech Republic. This relative undervaluation, however, may be partly due to the properties of the estimation technique.

If prices in Prague were systematically higher than in the rest of the Czech Republic in the past (as the data show), the panel regression will assign them the highest fixed effect in absolute terms compared to the other regions. This may mean that the conclusion that apartment prices in Prague are undervalued is based on explanatory variables which are not necessary equilibrium variables themselves. For illustration, there are roughly 14% more houses per 1,000 inhabitants in Prague compared to the average region, while wages are 38% higher, unemployment is around 50% lower, net migration is 4.5 times higher and lending for housing purposes per person is roughly 2.5 times higher. Given the still relatively short length of the available time series, there is thus a question as to whether the resulting "undervaluation" is in fact real. The conclusion that apartment prices in Prague are undervalued compared

to the other Czech regions is also inconsistent with the comparison of the price-to--income and price-to-rent ratios between regions, which indicate that Prague is, on the contrary, the highest-risk region (see Section 4 above).

For the evolution of the under/overvaluation of apartment prices in different regions, refer to *Figure 10*. This figure shows that apartments were overpriced for the whole period under consideration in Olomouc Region (M), Moravian-Silesian (Ostrava) Region (T), and Zlín Region (Z), and systematically underpriced in South Bohemian Region (C), Liberec Region (L), and Karlovy Vary Region (K). In Ústí nad Labem Region (U) and Plzeň Region (P) apartments were overpriced at the beginning of the period under scrutiny and underpriced at the end. The opposite was true for South Moravian (Brno) Region (B), Hradec Králové Region (H), and Prague (A). Prices in Vysočina (Jihlava) Region (J) and Pardubice Region (E) were generally near their equilibrium over the whole period. These results are in line with those of Zemčík (2011), who finds bubbles in Prague, Olomouc Region, and Hradec Králové Region.

8. Conclusions

In this paper we focused on analyzing property price determinants in the Czech regions using three simple approaches: analysis using *price-to-income* and *price-to-rent* ratios (including their international comparison), analysis using statistical filters and panel data regression. To the best of our knowledge, this is one of the first applications of econometric techniques to property prices in the Czech Republic and using information from regional data.[26] For this reason, and also because of difficulties associated with the properties of the analytical methods applied and with the relatively short time series used, the results of the analysis should be interpreted with caution.

That said, a number of conclusions can be drawn. Similarly to Čadil (2009) we found that housing prices in the Czech Republic are driven mainly by demand factors. The effects of supply factors were mixed: analyses showed building plot prices to be significant. In some specifications of the panel regression the number of apartments per 1,000 inhabitants was also significant. Of the demographic factors, regression confirmed a positive effect of natural population growth on property prices. This is in line with the results of Čadil (2009) and Lux and Sunega (2010).[27] For some specifications net migration and the divorce rate were also significant. The unemployment rate and wage growth turned out to be significant among the labor market--related demand factors (in line with Égert and Mihaljek, 2008, or Lux and Sunega, 2010). Rents also proved to be important factor of housing price growth, confirming the possibility of rental and owner-occupied housing substitution. This is in line with the outcomes of Zemčík (2011), who used rents as the main variable explaining apartment prices. However, potential endogeneity and the influence of housing market sentiment should be taken into account for apartment prices and for building plot

[26] Notable exceptions are papers by Čadil (2009), Zemčík (2011), Égert and Mihaljek (2008), Hlaváček and Komárek (2009a), Hlaváček and Komárek (2009b), Hlaváček and Komárek (2010) and Lux and Sunega (2010). These studies however often do not use regional data and are oriented on the Czech Republic as a whole, they often use limited set of explanatory variables.

[27] Čadil (2009) used the size of the population aged 20–39 as the explanatory variable, which is correlated with natural population growth. Lux and Sunega (2010) found link to the migration characteristics.

prices. An interesting result was that neither mortgage credit growth nor the credit conditions (represented by interest rates) were among the significant factors of apartment prices. This is different to the results of Égert and Mihaljek (2009), who applied panel regression to cross-country CEEC data. This might be because the differences in financial market developments are substantial across different countries but not very important in the cross-regional dimension within one state. On the other hand, the link between credit growth and apartment price dynamics in the Czech Republic seems to have been restored in the last 1.5 years. Contrary to us Lux and Sunega (2010) find in the long run relationship link between housing prices and interest rates but they argue, that this result is not satisfactory and might be result of short data series.[28]

Another result is the identification of periods when property prices were overvalued. As expected, all three approaches identified property price bubbles in 2002/ /2003 and 2007/2008. Rather surprisingly, however, the panel regression results have shown that the level of overvaluation in 2007/2008 was lower than in the first period, even though the increases in prices in the two periods were similar. Much of the rise in prices in 2007/2008 can be explained by fundamentals and the bubble is not as large as it might appear at first glance (e.g. using statistical filters). The influence of the recent financial crisis on apartment prices confirmed the appropriateness of our approach as compared to the "naive" Hodrick-Prescott filter, which identifies strong undervaluation of apartment prices in the first half of 2009. Our approach generally identifies the recent decline in apartment prices as a return to equilibrium. A further worsening of the impacts of the world financial crisis on the Czech economy could eventually lead to renewed inflation of the bubble "from below" via worsening fundamentals.

Looking at the individual regions, the level of overvaluation of apartment prices in individual regions is positively related to the apartment price level (in regions where apartment prices are higher, they are also more likely to be overvalued). Apartment prices in Prague are the exception to this rule, as the level of overvaluation is one of the lowest despite the fact that Prague has the highest absolute prices. This is probably due partly to the properties of the estimation technique, as the conclusion that apartment prices in Prague are relatively undervalued may be based on explanatory variables which are not necessarily equilibrium variables themselves. This outcome is therefore not wholly consistent with earlier simple analyses of the price-to-rent and price-to-income ratios as well as HP filter results that see Prague as the most risky region as far as housing price bubbles are concerned. It confirms that the property market in Prague is specific in nature compared to the other Czech regions.

[28] Both interest rates and house prices experienced trend in the period under scrutiny (downward trend in interest rates and upward trend in housing prices). However, developments in the crisis might have broken this relationship as the market interest rates dropped together with drop in housing prices.

Appendix 1 Sources of Data on Apartment Prices

	Time coverage (June 2009)	Periodicity	Published	Regional coverage	Source of data	Further info	Advantages	Disadvantages
Transfer prices (CZSO)	1998–2Q08	quarterly	yearly, estimates quarterly	Districts ("Kraje")	Publication "Ceny sledovaných druhů nemovitostí" (in Czech only) http://www.czso.cz/csu/2008edicniplan.nsf/p/7009-08	Prices of family houses, building plots, apartment blocks, and garages	- wide coverage according to types of real estate (apartments, family houses, apartment blocks, building plots, and garages) using comparable methodology and structure - data cover all transfers of second hand real property against payment - statistics cover all major districts - classification according to size of municipality and age of given real estate	- large time lag of publication (almost one year) - tax optimization by respondents might influence reported prices - includes only information on prices of transfers of already existing real estate; information on prices of new apartments is not included as they are not subject to property transfer tax
Supply prices (CZSO)	2004–1Q09	quarterly	quarterly	Prague vs. Rest of CZ	http://www.czso.cz/csu/redakce.nsf/i/ceny_bytu (in Czech)		- official source, methodology should be comparable to transfer prices - small time lag of publication	- low regional coverage (only Prague vs. rest of the Czech Republic) - time series available only from 2004
Supply prices (Institute for Regional Information – IRI)	2000–5/09	until 2006 yearly, from 2007 quarterly; Prague monthly starting from 3/04	quarterly	Regional capitals + other major towns (77 towns/ /cities in all)	Closed database, current prices available at http://bydleni.idnes.cz/ See also IRI (http://www.iri.name/)	Market and regulated rents	- longest data series of supply prices in Czech Republic (from 2000) - wide regional coverage - uses prices of "standard apartment" so is not influenced by problems with changes in structure of housing stock - also publishes supply market rents using the same methodology	- loses information on prices outside relatively thin market segment of "standard apartment" - database is not officially public
Supply prices (Dolanský)	2002–4/09	monthly	monthly	Selected towns (22)	Journal Realit (ISSN 1210-8308)	Prices of building plots and family houses, market rents (from 2007)	- published regularly starting from 2002 (at monthly frequency) - detailed classification for Prague - primary source for apartment supply prices published quarterly by CZSO	- some regional capitals are missing from database - regional coverage differs according to type of real property
Supply prices (King Sturge)	2005–present	monthly	yearly report	Selected towns + Prague in detail	Czech Residential Market report (website: www.kingsturge.cz)	Prices of family houses and apartments. Differentiates between prices of new and second hand apartments. Includes prediction for one year horizon.	- study available in English. In addition to data includes analysis and prediction of future developments - division of second hand and new apartments, analysis of different types of real property - detailed analysis of Prague	- base study published only once a year (more detailed studies can be prepared on commercial basis) - only partial regional coverage

Appendix 2 Correlations between Different Indexes According to Lags

	Lag (Q)	Transfer prices CZSO	Supply prices CZSO	Supply prices (Dolanský)	Supply prices (IRI)	Supply prices (King Sturge)
Transfer prices CZSO	0	*1*	0.8756*	0.8527*	0.9315*	0.8894*
	1	*0.9140**	0.8945*	0.8603*	0.8517*	0.6086
	2	*0.7098**	0.8104*	0.7626*	0.6580*	0.1685
	3	*0.4558*	0.7344*	0.5860*	0.4337	-0.2229
	4	*0.2253*	0.6084*	0.4032	0.1672	-0.5401
Supply prices CZSO	0	0.8756*	*1*	0.9931*	0.8940*	0.3577
	1	0.8051*	*0.8958**	0.8740*	0.6593*	-0.2562
	2	0.7326*	*0.7085**	0.5869	0.3774	-0.2926
	3	0.6024	*0.4642*	0.2562	0.0865	-0.3958
	4	0.4261	*0.2888*	-0.0708	-0.1260	-0.4430
Supply prices (Dolanský)	0	0.8527*	0.9931*	*1*	0.9047*	0.5846
	1	0.7885*	0.9288*	*0.9030**	0.7190*	-0.0786
	2	0.6979*	0.7697*	*0.6722**	0.4736	-0.1235
	3	0.5223	0.5691	*0.4082*	0.2529	-0.2676
	4	0.2892	0.4013	*0.1530*	0.0432	-0.3597
Supply prices (IRI)	0	0.9315*	0.8940*	0.9047*	*1*	0.9050*
	1	0.9024*	0.9760*	0.9603*	*0.9026**	0.5133
	2	0.8301*	0.9131*	0.8761*	*0.7367**	0.0587
	3	0.7375*	0.7830*	0.6717*	*0.5182*	-0.2695
	4	0.6281*	0.6269*	0.4468	*0.3012*	-0.3772
Supply prices (King Sturge)	0	0.8894*	0.3577	0.5846	0.9050*	*1*
	1	0.6688	0.8352*	0.8771*	0.8906*	*0.6944*
	2	-0.0249	0.9008*	0.8665*	0.7985*	*0.2556*
	3	-0.6598	0.6778	0.8461*	0.5751	*-0.3103*
	4	-0.9476	0.4290	0.6140	0.2526	*-0.7709*

Notes: The table depicts the correlation of the given source of data for Prague to see whether one source "leads" the others. For example, the first block depicts the dependence of Czech Statistical Office transfer prices on lagged values from the other sources. The significance level of 99% is depicted by *. Cells highlighted in dark grey depict the highest correlation coefficient for the given lag. Cells highlighted in light gray depict the second highest coefficient. Cells in italics depict the correlations of the given variable with its lagged values.

Appendix 3 Panel Unit Root Tests

Variable	levels		differences	
	homo	heter	homo	heter
Apartment prices	1.906 (0.0283)	1.997 (0.0229)	-0.098 (0.5389)	-0.283 (0.6113)
Building plot prices	8.336 (0.0000)	3.480 (0.0003)	-1.318(0.9062)	0.540 (0.2945)
Apartment construction prices	1.441 (0.0748)	2.023 (0.0215)	-1.831 (0.9664)	-1.610 (0.9463)
Completed apartments	-0.286 (0.6126)	0.781 (0.2175)	-2.243 (0.9875)	-2.214 (0.9866)
No. of apartments per 1,000 inhab.	2.361 (0.0091)	1.480 (0.0695)	-0.026 (0.5103)	0.020 (0.4919)
Marriages	1.680 (0.0464)	1.470 (0.0707)	-2.397 (0.9917)	-2.320 (0.9898)
Divorces	-0.687 (0.7539)	0.334 (0.3693)	-0.344 (0.6347)	-0.492 (0.6885)
Natural population growth	1.412 (0.0790)	0.843 (0.1998)	-1.138 (0.8724)	-0.961 (0.8316)
Net migration	1.014 (0.1552)	2.258 (0.0120)	-2.811 (0.9975)	-1.978 (0.9760)
Unemployment rate	3.077 (0.0010)	2.233 (0.0128)	-0.204 (0.5807)	-0.407 (0.6580)
Economic activity rate of population	1.858 (0.0316)	1.364 (0.0863)	-0.833 (0.7975)	-0.397 (0.6544)
Vacancies/labor force	2.177 (0.0147)	2.166 (0.0151)	0.558 (0.2886)	0.711 (0.2384)
Average monthly wage	1.914 (0.0278)	1.892 (0.0292)	0.260 (0.3973)	0.214 (0.4151)
Rent per month	8.839 (0.0000)	7.013 (0.0000)	-0.401 (0.6560)	-0.229 (0.5906)
Loans	12.820 (0.0000)	12.257 (0.0000)	-1.336 (0.9093)	-1.133 (0.8715)
1Y Pribor	-0.930 (0.8238)	-0.930 (0.8238)	-2.123 (0.9831)	-2.123 (0.9831)

Notes: H0: all 13 time series in the panel are stationary processes; Homo: homoskedastic disturbances across units; Hetero: heteroskedastic disturbances across units; shaded cells highlight the series which are seen as stationary.

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